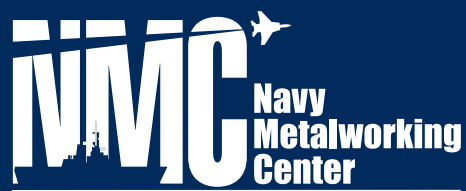


Advanced Metalworking Solutions for Naval Systems That Go in Harm's Way



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Front Cover

Left: DDG 98 guided missile destroyer. Northrop Grumman photo. Top, Middle: Conceptual design of LCS surface ship. Northrop Grumman photo. Top, Right: Two HH-60H Seahawk helicopters hover in front of the Nimitz-Class aircraft carrier, CVN 71. U.S. Navy photo. Bottom, Left: Los Angeles-Class fast attack submarine, SSN 706. U.S. Navy photo. Bottom, Middle: Conceptual design of DD(X). Northrop Grumman photo. Bottom, Right: Family member welcomes home the USS Winston S. Churchill (DDG 81). U.S. Navy photo.

Back Cover

Left: X-45C J-UCAS conceptual drawing. The Boeing Company photo. Top, Middle: Arrested landing of an F/A-18E Super Hornet on the USS Nimitz (CVN 68). U.S. Navy photo. Top, Right: M777 Lightweight 155mm Howitzer. BAE Systems photo. Bottom, Left: Friction stir welding. Cramer Studio, Inc. photo. Bottom, Middle: VIRGINIA (SSN 774) submarine. U.S. Navy photo. Bottom, Right: MH-60R Seahawk helicopter. U.S. Navy photo.

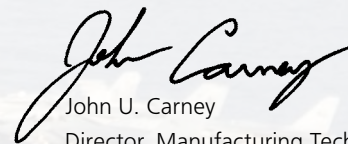
D I R E C T O R S ' L E T T E R S

The Navy Manufacturing Technology Program (ManTech) continues to refine its approach to best meet the needs of the fleet. Our investment strategy, which was initiated in 2004, operates under a platform-centric method of execution that concentrates ManTech resources primarily on key Navy platforms to make a measurable impact. Transition to the industrial base producing key Navy platforms and, ultimately, transition to the fleet is our goal. ManTech resources currently are focused on the following high-priority naval platforms: CVN 78, DDG 1000, VIRGINIA-Class Submarines (VCS) and the Littoral Combat Ship (LCS).

In 2006, RADM Admiral Landay, Chief of Naval Research, offered the ManTech Program a tremendous opportunity to help meet top-level Navy objectives by impacting the unit cost per ship. The major ship platforms are seeking unit cost reductions in order to fund the number of ships planned by the Navy. Navy ManTech has been asked to take on greater responsibility and to make significant contributions to meeting the overall cost-reduction goals. To answer RADM Admiral Landay's call, the majority of ManTech Program resources are now focused on shipbuilding affordability efforts that will decrease acquisition cost, in particular, reducing the cost per hull for the targeted ship classes.

This annual report highlights Navy Metalworking Center's (NMC) efforts to develop advanced metalworking and manufacturing technologies that reduce cost, improve performance, and enhance responsiveness. NMC's current and upcoming projects support the ManTech investment strategy and are platform-centric and affordability-focused. Greg Woods, the ManTech Program Officer; Dan Winterscheidt, the NMC Program Director; and NMC staff are working with industry and the Program Offices for CVN 78, DDG 1000, LCS and VCS to select and execute projects that will reduce acquisition costs and address manufacturing earlier in the development cycle for maximum impact.

I hope you will gain an appreciation for the role that NMC plays in achieving the goals of ManTech's Shipbuilding Affordability Initiative. I have confidence in the leadership and staff of the NMC, and believe that they will continue to strive for technical excellence and successfully transition affordable metalworking and manufacturing processes to the production lines of Navy weapon systems.



John U. Carney
Director, Manufacturing Technology Program
Office of Navy Research



The Navy ManTech Program continues to evolve. Today, ManTech focuses on specific platforms, has increased accountability for its resources and value to the weapon systems, and has greater emphasis on technology transition. To meet these changing requirements and expectations, we continue to adjust our mindset and mode of operation.

Responding to change isn't a new development. Over the years, we've adapted the Program to meet the changing needs and environment of both the Navy and the ManTech Program. We have aligned our project portfolio to support the ManTech investment strategy and are executing current and new projects for CVN 78, DDG 1000, VIRGINIA-Class Submarines and LCS. During the last several years, our projects have emphasized practical technology, and we have made a concerted effort to work with our industry partners to initiate projects that are focused on the needs of the weapon systems Program Office, provide good return on investment, and have a high probability of successful transition.

Today, the focus of Navy ManTech is on shipbuilding affordability. NMC has a number of active projects and several new starts that will significantly contribute to the goal of reducing ship construction costs.

The introduction of more productive and cost-effective metalworking processes is a key component of the shipbuilding affordability focus. NMC is playing a critical role in ensuring that performance-enhancing metallic materials as well as advanced shapemaking, forming, joining, and coating methods and other affordable technologies are incorporated into manufacturing processes for naval weapon systems.

In this annual report, you will read about a number of NMC projects that are poised for transition on CVN 78 and DDG 1000 – projects that involve high strength-to-weight ratio materials and advanced manufacturing processes, such as LASCOR, high strength and toughness steel, and hull treatment. We are also executing important projects in support of NAVAIR and the Marine Corps.

Change is inevitable. American writer and journalist John Hersey said, "The reality is that changes are coming.... They must come. You must share in bringing them." As the Navy Metalworking Center, we understand that our role is to serve as an agent of change and our responsibility is to ensure that advanced and affordable metalworking solutions are transitioned to naval systems that go in harm's way.



Daniel L. Winterscheidt, Ph.D.
Program Director, Navy Metalworking Center

Aircraft Carriers

Optimizing materials and manufacturing processes



Conceptual design of CVN 21. Northrop Grumman.

The mighty aircraft carrier has long been the capital ship in the U.S. Navy fleet. Carriers have proven to be highly valuable to the U.S. military, operating strike fighters and other tactical aircraft, embarking U.S. Army forces and special operations, and supporting humanitarian and non-military causes.

CVN 21 is the U.S. Navy's next planned generation of aircraft carrier—the warship for the 21st Century. This new class of carrier will meet the demanding operational requirements of the U.S. Navy; realize a reduction in acquisition costs, operational manpower, and weight; while at the same time, enhance warfighting capabilities.

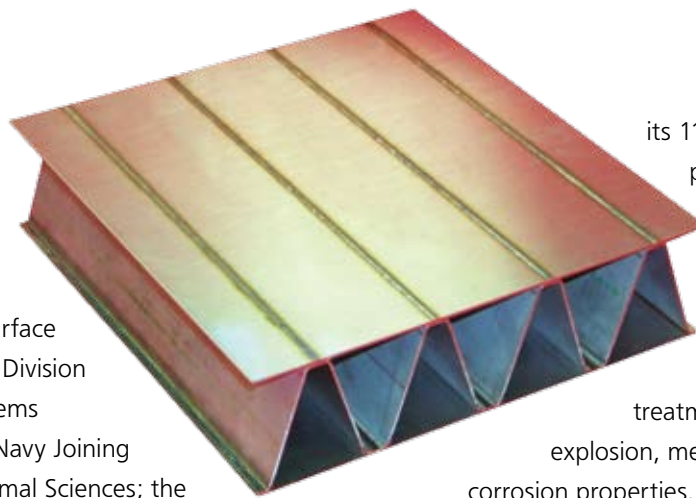
The Navy Metalworking Center (NMC) has been playing a major role in helping to develop materials and manufacturing processes for CVN 78—the first ship in the CVN 21-Class. Together with government and industry partners, NMC has developed advancements in high-strength steels and

lightweight, corrosion-resistant structures, as well as welding enhancements that will go a long way in helping to reduce costs associated with constructing the next generation of super carriers.

Advancing LASCOR Technology

Lower center of gravity and reduced weight are key performance parameters of the CVN 21-Class aircraft carrier. In order to achieve this, the use of stiff, lightweight, metallic sandwich panels called LASCOR (LASer-welded corrugated-CORE) is being considered. Since LASCOR panels have not been proven in critical applications nor has technology for its use been established, NMC is leading a project team to explore the use of LASCOR panels. In particular, joint and stud attachments to the ship structure, manufacturing fabrication procedures, and shipyard repair methods for LASCOR need to be developed.

A I R C R A F T C A R R I E R S



NMC, as part of a multifaceted Integrated Project Team (IPT) that includes the Future Aircraft Carriers Program Office (PMS 378); Naval Surface Warfare Center, Carderock Division (NSWCCD); Naval Sea Systems Command (NAVSEA); the Navy Joining Center (NJC); Applied Thermal Sciences; the Institute for Manufacturing and Sustainment Technologies (iMAST); and Northrop Grumman Newport News (NGNN), is working to further develop the use of LASCOR panels for shipbuilding purposes.

NMC is focusing on design details for LASCOR and establishing processes, evaluations, and procedures for panel implementation and shipyard use. If implemented, LASCOR technology can result in an overall weight savings of 15 to 35% per application as compared to legacy designs. Additional cost savings can be realized through reduced life-cycle maintenance costs, increased ship compartment usable volume, modular fabrication, elimination of stiffeners, distortion reduction, and increased corrosion resistance. This technology may also be applied to doors, decks, islands, and bulkheads.

Evaluating High Strength and Toughness Steel Materials

Another approach for reducing the weight of CVN 21 is the use of high strength and toughness steels. Preliminary laboratory studies indicated that these materials had the potential to provide increased protection and strength at reduced weight. It was unknown how these materials would perform during manufacturing, particularly the welding process, although research has shown that these steels may be easily weldable because of their low carbon content and clean melt practices. NMC is working on two projects involving manufacturing issues related to high strength and toughness steels.

In order to help prepare shipyards for the implementation of HSLA-115 (an improved version of HSLA-100 steel named for

its 115 ksi minimum yield strength), NMC is part of an IPT working to identify and address potential issues early in the development stage. The program has been tasked with evaluating the production of these high strength and toughness steels, optimizing heat treatments, and analyzing material, ballistic, explosion, mechanical, structural, welding, and corrosion properties.

A second project includes performing extensive metallurgical evaluations; investigating heat treatments; evaluating hot and cold forming effects, structural performance, and mechanical properties; and recommending fabrication procedures and procurement specifications based on the findings. This IPT includes PMS 378, NSWCCD, Mittal Steel USA, NJC, NAVSEA, QuesTek Innovations L.L.C., Aberdeen Test Center, and NGNN.

Testing the Use of Titanium

Because of its high tensile strength—even at high temperatures—light weight, extraordinary corrosion resistance, and ability to withstand extreme temperatures, titanium alloy was considered as a replacement for some steel components on CVN 21.

NMC worked with PEO (Carriers), NSWCCD, NAVSEA, NJC, and NGNN to identify, develop, evaluate and demonstrate suitable manufacturing techniques for titanium naval components that will reduce weight on CVN 21-Class aircraft carriers and increase the depth of shipyard experience in the application of titanium components. While the project successfully identified candidate and demonstration components and evaluated application and manufacturing options, the CVN 78 Program determined that the carrier's overall weight goal will be met, thus eliminating the need for the development of titanium components. Although the use of titanium cannot be cost justified at present, breakthrough methods of titanium processing are currently in development. After these processes are demonstrated on a production scale, the use of lower cost titanium may be considered on future applications.



NMC has been playing a major role in the materials and manufacturing development of the CVN 21 concept aircraft carrier. Here, the USS Harry S. Truman (CVN 75) is the home base for an F/A Hornet preparing to land. U.S. Navy photo.

Constructing and Analyzing a Weld Distortion Test Structure

Correcting weld distortion can add considerable time and expense in ship construction. Since most distortion can only be removed through a trial-and-error flame straightening process by experienced personnel, significant cost savings can be achieved by performing iterations on the welding process and sequence in a physics-based simulation. To date, commercially available software for predicting weld distortion has not been applied to the massive structures encountered in shipbuilding. Team members Battelle Memorial Institute, ESI North America, and Optimal, Inc. helped model a mock-up foundation assembly that NMC built to evaluate and predict weld distortion.

The result is the construction of a 12.5-ft. x 11.5-ft. x 5-ft. generic demonstration ship innerbottom. NMC built the structure under carefully controlled conditions. The weld sequence of the mock-up is designed to maximize induced

distortion for comparison with the welding simulation. Two weld distortion analysis software programs are being used to simulate the welding process based on the welding parameters for CVN 21. The distortion predicted by the software programs will be compared against the actual data. This project is being coordinated with another project managed by the Center for Naval Shipbuilding Technology and NGNN.

Welding Improvements Lead to Cost Savings

In order to achieve optimal ballistic performance, MIL-10718-M is the electrode conductor used for all undermatched shielded metal arc welding (SMAW) of HSLA-100 and HY-100 steels in the construction of CVN 78. This electrode was only available in 1/8-inch diameter and had an unusually high rejection rate during testing at NGNN. NMC worked with two electrode manufacturers to optimize the 1/8-inch diameter and further developed a 3/32-inch diameter, providing two diameters of MIL-10718-M electrodes for flexibility in construction.

Subsequently, the manufacturers provided multiple lots of both sizes of electrodes to NGNN and General Dynamics Electric Boat (EB), the systems integrator for the VIRGINIA (SSN 774) submarine. Both shipyards were satisfied with the operating characteristics, weld metal mechanical properties, and weld appeal of the 1/8-inch electrode. The 3/32-inch electrode is still under development. The consistent availability of two diameters of MIL-10718-M electrodes will result in more cost-effective naval vessel production and efficient manufacturing.



A mock-up of a generic ship innerbottom was constructed in order for NMC to test weld sequences for CVN 21. CTC photo.

Developing Repair Technology

On another project funded by ONR and overseen by NAVSEA, NMC is working with Spiritech Incorporated to develop a mobile abrasive waterjet-cutting system prototype for shipyard demonstration and implementation. The project team includes Penn State University/Applied Research Laboratory Repair Technologies, Norfolk Naval Shipyard, Puget Sound Naval Shipyard, Portsmouth Naval Shipyard, Pearl Harbor Naval Shipyard, and NAVSEA.

The use of waterjet-cutting technology in dry-dock applications is limited because typically workstations are used to process parts within the manufacturing line. This makes it difficult or impossible to work in “on-site” situations, such as a ship hull, because the structure being cut cannot be accommodated by the workstation. In order to take advantage of the benefits of waterjet-cutting technology a mobile abrasive waterjet-cutting system is being developed. This system will allow shipyards to apply and further develop the technology for specific applications and requirements.

New Projects Reduce Costs, Address Technical Challenges

In order to reduce costs associated with maintenance and extend the overall service life of the carrier, NMC will lead a project to develop manufacturing processes for alloy 625 components. This nickel-based superalloy possesses excellent resistance to oxidation and corrosion while also exhibiting outstanding strength and toughness at extremely high temperatures. Alloy 625 also has a reputation for being difficult to form and weld. This project will focus on developing the required knowledge to help NGNN implement cost-effective manufacturing processes for the use of alloy 625. Team members include PMS 378, NSWCCD, and NGNN.

Another cost-reduction initiative addresses methods to achieve stringent requirements for steel surfaces prior to blasting and painting. In order to ensure proper coating adhesion, to minimize the possibility of paint blistering or peeling, and to improve the service life of the paint system, naval requirements specify certain surface conditions. Steel surfaces must be blasted to near-white conditions, possess a specific surface

profile, and be free of contaminants. Atmospheric conditions must also be met for steel blasting and for the application and cure processes of tank paint systems.

NMC will be leading a project team consisting of PMS 378, NAVSEA, and NGNN to develop an efficient cleaning process that will meet specifications prior to blasting and painting operations. Specifically, NMC will quantify the sources of contamination throughout the construction process, evaluate various cleaning methods, and determine the most cost-effective stage of construction to implement the selected procedures.

With these innovations and many others being developed, NMC is providing affordable materials and manufacturing processes that are making it possible to achieve the challenging performance and cost goals for the next generation of aircraft carriers.



NMC is working on several advanced metalworking projects for CVN 78. Here, the USS Theodore Roosevelt (CVN 71) leads a formation with a Spanish Navy frigate and the guided missile destroyer USS Donald Cook. U.S. Navy photo.

Ships and Submarines

Improving manufacturing and reducing construction costs



Conceptual design of LCS. Northrop Grumman.

Since the American Revolutionary War, U.S. Navy vessels have been providing forward presence and deterrence. Today, the next generation of multi-mission destroyers and submarines are being developed and will continue to serve an integral role in keeping our seas safe. NMC is currently playing a critical role in developing advanced metalworking and manufacturing processes for the DDG 1000 multi-mission destroyer, the Littoral Combat Ship (LCS) and VIRGINIA (SSN 774) submarine.

Advancing Friction Stir Welding for Ship Construction

LCS is the first of a new family of networked surface ships for the U.S. Navy. Designed to be fast and highly maneuverable, LCS satisfies the need for shallow draft vessels that operate in coastal waters.

The LCS designs incorporate significant amounts of aluminum. Friction Stir Welding (FSW) is an ideal joining process for

aluminum. This process is a vast improvement over conventional marine aluminum construction because it offers decreased distortion, improved joint properties, and reduced production costs.

NMC, together with IPT partners that include the LCS Program Office, Lockheed Martin, Marinette Marine Corporation, Bollinger Shipyards, NAVSEA, and American Bureau of Shipping, is leading a project to design, build, and evaluate the first low-cost FSW machine to be housed at a shipyard.

By limiting functionality to the specific needs of LCS, the machine will be less costly and provide a faster return on investment for the shipyard. Because the FSW operation will be located at the construction yard, the panels used in construction can be built to size rather than limited to a size that can be transported. The machine's simplified controls and operation will also reduce the skill set and technical support required for the operator.

In another initiative for LCS, NMC has also identified new pipe bending capabilities in support of Bollinger Shipyards' Lockport LCS effort. NMC determined pipe spool design software and equipment interface capabilities, along with functionality and availability of pipe bending equipment, for a variety of pipe sizes and schedules applicable to the LCS design.

Reducing Construction Costs of DDG 1000

DDG 1000 is considered to be the backbone of tomorrow's surface fleet. This multi-mission destroyer is tailored for land attack and features a broad range of capabilities that are vital in supporting the global war on terror and major combatant operations. DDG 1000 is the lead guided missile destroyer in the ZUMWALT-Class developed under the DD(X) Program.

In order to make DDG 1000 more affordable, hull treatment (HT) has been targeted for material and process optimization. A savings in production costs and construction time could be realized with a less cumbersome application material. NMC, together with NSWCCD, NJC, Northrop Grumman Ship Systems (NGSS), Bath Iron Works (BIW), NAVSEA and the DDG 1000 Program Office, are evaluating alternative materials and HT installation processes. This project will also generate a guidance document for the physical enclosure required to support the installation of HT and will help integrate the process into the construction yards.



NMC is working on several projects to reduce construction costs of DDG 1000, the lead guided missile destroyer in the ZUMWALT-Class. Northrop Grumman.

The project is expected to result in a 27 to 60% reduction in the cost of HT installation. By developing a similar environmental enclosure that can be used by both installation shipyards, a 30% cost savings will be realized when compared to each yard developing its own enclosure. In addition, a 33% reduction is expected by integrating the installation process at both shipyards.

NMC has developed two new projects to address critical DDG 1000 Program needs. For the Peripheral Vertical Launch System (PVLS), the tee-shaped cross sections are fabricated by welding HSLA-100 steel plates lengthwise. During dynamic testing, distortion and weld fractures occurred. NMC will be helping to develop single-piece, cast steel tee-sections. The expected outcome will improve the reliability of the structure and may also reduce procurement and weld fabrication costs. Team members include NSWCCD, NGSS, BIW, the DDG 1000 Program Office (PMS 500), NAVSEA, Southwest Research Institute, and casting foundries.

The second project is focused on the MK100 Advanced Gun System (AGS) pallet, which is used to package, handle, store, and transport the long-range land attack projectile charges through the logistic channels and within the AGS magazine for DDG 1000. NMC will be leading a project to reduce the cost and decrease the weight of the AGS pallet by 20%. NSWCCD, NSWC Dahlgren and Port Hueneme Divisions, PEO IWS 3C Program Office, and BAE Systems are the team members for the project.

Reducing Manufacturing and Assembly Costs for VIRGINIA (SSN 774) Submarines

The VIRGINIA (SSN 774) submarine is an advanced stealth, multi-mission, nuclear-powered, attack sub designed for deep ocean anti-submarine warfare and littoral missions. NMC has developed several new projects focused on reducing manufacturing and assembly costs. NMC will be managing a project team to investigate the implementation of more cost-effective pipe fitting methods in submarine systems. Specifically, the project will investigate replacing butt and socket welded joints with options that require less preparation and joining time as well as simplifying inspection procedures.

This effort will also evaluate the industrial availability and implementation of belled end fittings applicable to submarine systems, in order to provide a reduced cost alternative to butt welded fittings in pipe sizes above 2 NPS (nominal pipe size). The benefits will include reduced end preparation and fit-up times and result in significant cost improvements in submarine construction. NMC will be working with EB, NAVSEA, NGNN, and the VIRGINIA-Class Program Office.

On another project, NMC, together with EB, NAVSEA, NSWCCD, the VIRGINIA-Class Program Office, and NJC, will work to develop cost-effective methods to minimize defects during root pass welding for large diameter alloy 625 pipe welds. The radiographic rejection rate for these welds has historically been one of the shipyard's highest when compared to other welded materials, and has resulted in schedule delays and hundreds of additional man-hours. Successful development and implementation of new pipe welding techniques and alloy 625 processes will result in decreased fabrication time and costs due to minimized schedule delays.

NMC has also developed an additional cost-reduction project that will identify and qualify alternative damping materials that can be applied more efficiently to the VIRGINIA (SSN 744) submarine. Damping materials are used to reduce vibration. The tiles must meet MIL-PRF-23653, MIL-DTL-24487, and MIL-A-24456 requirements, which include damping characteristics, adhesion strengths in peel and shock, toxicity, flame retardancy and others. The application process for the tiles is labor intensive and has significant potential for reduction. NMC will work with EB, NAVSEA, NSWCCD, NGNN and the VIRGINIA-CLASS Program Office to identify and qualify alternative damping materials that can be applied more efficiently. The project will result in cost reductions for the Navy.

Researching and Developing New Materials

NMC continues to support research and development efforts to identify and evaluate advanced materials and processes that will benefit U.S. Navy shipbuilding under ongoing and new projects for NAVSEA. Through the Metallic Materials Advanced Development and Certification Project (MMADCP), NMC continues to provide research, development, testing, and evaluation of new materials and processes for Navy

shipbuilding programs. Past successes include HSLA-65 testing for certification and procurement on CVN 78, and production methods and testing of large high strength marine grade fasteners, including procurement specifications for Ti-5111, MP98T, alloy 59, alloy 686, and others. These fasteners offer significant reductions in life-cycle costs for current and future applications. MMADCP also provided the first steps toward a high strength and toughness steel for CVN 78 (see page 3). The Navy Materials Properties Database (NMATDB) was also established by MMADCP. The database compiles over 1,200 historical Navy material test reports, as well as the test results of all MMADCP tasks, and will support design agents making materials selections for critical ship system applications.

Going forward, NMC will provide data and support for the NMATDB, develop and test concepts for joining steels to composites and steels to aluminum, develop welding methodologies, support large-scale testing of non-magnetic stainless steel AL6XN, complete testing and draft procurement specifications for a high strength and toughness machinery material (15-5 PH), and finalize characterization of Ti-5111.

In a new project, NMC will work with experienced ship design firms, NAVSEA, and NSWCCD to define the properties that drive the design for many major ship systems. The project will review composite-to-metal joining technologies, and evolving technologies developed under related Navy efforts. Emerging steel alloys will be closely examined to determine whether pricing and shipyard manufacturing criteria are suitable for introduction into shipyard applications.

The NMC project will document innovative material and manufacturing technologies that can improve performance and reduce cost on various naval platforms. NMC will also leverage past friction stir weld initiatives and develop ways of optimizing friction stir processes for shipbuilding. NMC will collaborate with NSWCCD to define the appropriate friction stir welding and friction stir weld processing tasks to best transition these technologies to naval applications.

NMC is providing new technologies that offer system performance and shipbuilding productivity innovations, enabling the Navy to achieve desired performance, reduce manufacturing costs, and improve overall shipbuilding efforts.

Aircraft

Advancing high-performance technologies



Conceptual design of X-47A J-UCAS air vehicle, Northrop Grumman.

Aircraft have been a part of U.S. Naval operations since the early 1900s. Today over 4,000 aircraft are part of the Navy's fleet. NMC is helping to ensure Navy dominance on the seas and in the air with projects that explore the use of new materials and technologies that reduce manufacturing and maintenance costs.

Innovating N-UCAS Manufacturing

The Navy Unmanned Combat Air Systems (N-UCAS) Advanced Development Program is developing a high-performance, weaponized, unmanned aircraft for 21st Century combat missions. NMC is working to achieve both cost and weight reduction in the N-UCAS Wing Outboard Fuselage (WOF) and other airframe components.

Two manufacturing technologies, advanced high speed machining (HSM) and electron beam free form fabrication (EBFFF), were selected from a prior project for further

development. The HSM technology will be used to manufacture ultra-thin aluminum spars while the EBFFF technology will be used to produce lower-cost titanium components. The project will include the fabrication and testing of a full-scale wing outboard fuselage using both technologies. A total manufacturing cost savings and life-cycle operating cost avoidance of \$105 million could be realized, assuming the purchase of 150 N-UCAS aircraft. This project is being coordinated with a Systems Design and Manufacturing Development effort managed by the Composites Manufacturing Technology Center. Team members for this project include N-UCAS Advanced Development Program Office, The Boeing Company, and Naval Air Systems Command (NAVAIR).

Keeping the Rotary-Winged Warriors Flying

MH-60R is the newest multi-mission, maritime-dominance helicopter that is designed to operate from frigates, destroyers,

A I R C R A F T

cruisers, and aircraft carriers. Introduced in January 2006, MH-60R has improved capabilities that enable it to perform the missions of both the SH-60B and SH-60F weapon systems.

NMC has initiated a NAVAIR- sponsored project in support of the MH-60R helicopter. This project will address items on the MH-60R design improvement list, including maintainability, corrosion prevention, tooling design, mission kit support, and improved manufacturing. NMC is working with Sikorsky Aircraft Corporation (SAC), Cherry Point In-Service Support Team, and NAVAIR. NMC engineering efforts will include design, analysis, computer-aided design, and manufacturing support.

NMC also completed a Dynamic Components Redesign Study for NAVAIR that reviewed existing aircraft processes and component designs to improve the service life of the H-60 helicopter's dynamic components.

NMC has developed a new project to reduce corrosion-related maintenance and repair costs. This project has targeted implementation on the H-53E, the largest and heaviest helicopter in the U.S. military. NMC will work with NAVAIR PMA 299, Cherry Point In-Service Support Team and SAC to optimize the transmission housings to substantially reduce maintenance and replacement costs while producing a weight-neutral solution.

New Technologies to Extend Aircraft Life

Peening is a process that strengthens metal. It began when a ball-peen hammer was used to pound metal into shape while also strengthening it against fatigue failure. Later, shot peening pneumatically bombarded metal with tiny ceramic or metal beads. Today both ultrasonic and laser energy methods are being developed to improve fatigue life.

NMC is managing a project through ONR to evaluate the potential benefits of laser peening on selected aircraft components in the U.S. Navy inventory. Laser peening can induce residual compressive stresses into metal surfaces that are four times deeper than those obtained from shot peening. The added depth is key to laser peening's superior ability to keep cracks from propagating while extending the life of metal parts three to five times over that provided by conventional treatments. The project will evaluate the residual stress level and compressive layer depth as a function of laser beam intensity; develop a model that predicts residual stress distribution, including location and distribution of positive stress profiles; and conduct metallurgical evaluations of specimens to determine defect characteristics after peening and surface finishing.

On these critical projects, NMC is serving in a lead role to develop, evaluate, and transition cost-effective metalworking technology to ensure the superiority of U.S. naval aviation.



The MH-60R is the newest multi-mission helicopter. NMC is working on design improvements for MH-60R. Here, an MH-60R Strikehawk picks up cargo from a frigate during a replenishment with the USS John C. Stennis (CVN 74). U.S. Navy photo.

Ground Weapon Systems

Developing the weapon systems of the future



Today's warfighters must be ready to engage at a moment's notice. The weapon systems needed to support their efforts must be lightweight, reliable, and responsive. NMC and its industry partners are working not only to meet the needs of the current and future warfighter but also to produce those weapon systems in a cost-effective manner.

Advancing Howitzer Technology

The howitzer has been a mainstay in our country's arsenal of field artillery since the days of World War I. The 21st Century version of this weapon allows for greater mobility and quicker battlefield response. The M777 Lightweight 155mm Howitzer (LW155) utilizes titanium in place of steel. The use of titanium alloys in place of steel reduced the weight of each gun from 16,000 to 9,000 pounds, resulting in substantial improvements in transport logistics and weapon set up time.

Advanced metalworking processes are being applied to improve performance and reduce manufacturing costs for the

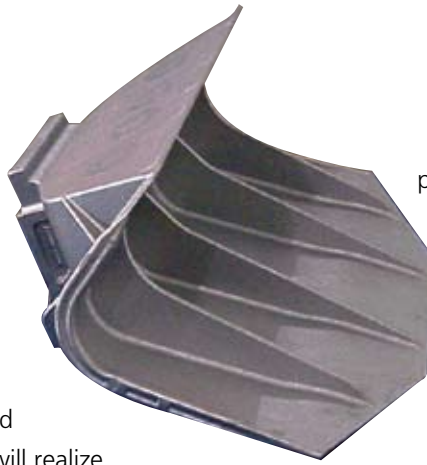
LW155. Because titanium product forms are several times more expensive than steel and the associated manufacturing processes are more complex for titanium than for steel, NMC developed and implemented new manufacturing approaches and technologies to reduce the part count, manufacturing costs, and material waste for the LW155.

Working with the LW155 Joint Program Management Office (JPMO) of Picatinny Arsenal, BAE Systems, and titanium foundries, NMC developed single-piece investment cast spades for the LW155. The spades stabilize the weapon during firing. Previously they were fabricated by machining and welding 60 individual parts. The project has reduced the 60 parts into one with a near-net-shape spade casting and has saved the program \$27 million. The cast spades were implemented into full rate production in March 2005.

The project also demonstrated a 110 to one reduction in part count of the saddle and developed alternative sources of raw

materials and novel production paths to eliminate machining-intensive production processes. For the LW155's cradle tube, NMC used flowforming, which resulted in 68% cost savings relative to baseline production methods. The expansion of the vendor network for the cradle tubes enhanced the supply redundancy for the program and will realize a cost avoidance of \$13 million over the full-rate production contract.

Another cost-reduction project addresses two joined components on the LW155, a muzzle brake and tow bracket that were experiencing weld failures during field testing. NMC is developing a single-piece steel casting that replaces the two components and eliminates the weld. The project is anticipated to result in an \$8.1 million savings with even higher cost avoidance realized with the retrofitting of replacement



parts over the lifetime of the weapon. NMC is working with the LW155 JPMO, MetalTek International, and Wollaston Alloys on this project.

Developing the Next Generation of Weapon Systems

Advances in technology have greatly changed the methods and weapon systems used to defend our country. NMC is working to help develop the next generation of weapons and take those new concepts from blueprint to the battlefield.

The next generation of ground combat vehicles will have improved structural and ballistic performance at reduced weights. NMC has a history of developing advanced materials and manufacturing technologies to help accomplish these goals. Working with the U.S. Army Tank Automotive Research, Development and Engineering Center and combat vehicle program managers and manufacturers, NMC is helping to transition advanced lightweight materials, novel designs, and innovative processing technologies.

Building on the advances in metals and joining technologies, NMC is developing and demonstrating manufacturing technologies that will reduce the weight and improve the total affordability of the next generation of combat vehicles. By applying high-strength aluminum-lithium and low-cost titanium alloys; novel FSW technology; and the combination of advanced metallics, ceramics, and polymers for improved weight-efficient armor for the combat vehicle community, NMC is helping to achieve the goal of producing lightweight vehicles with maintainable, cost-effective life cycles.

Through collaboration that has resulted in advanced processes, innovative materials, and new applications that are lightweight and cost-effective, NMC will meet the challenge and help turn future ground weapon systems concepts into realities.

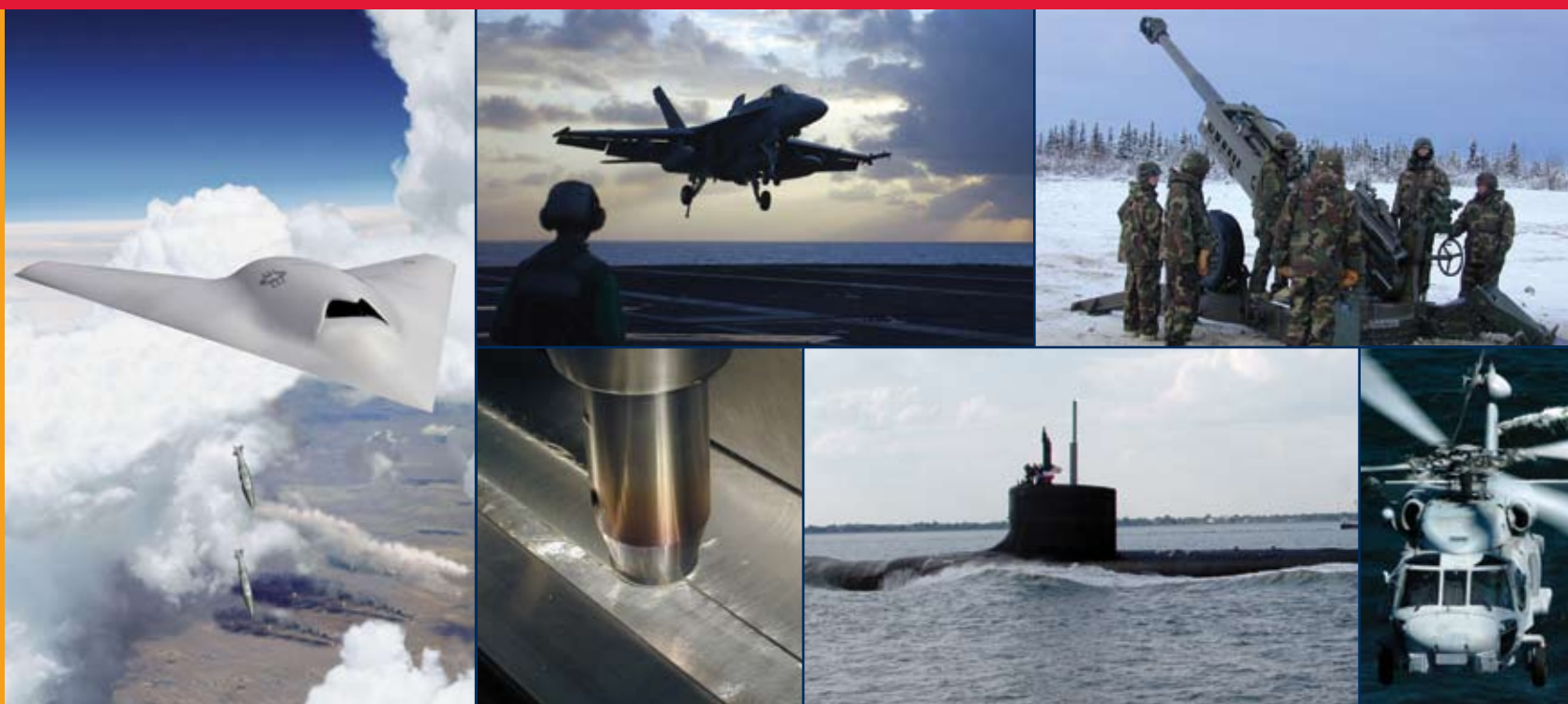


NMC is improving the structural and ballistic performance of the next generation of ground weapon systems. Here, the Non-Line-of-Sight Cannon Concept Technology Demonstrator is fired. BAE Systems photo.



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